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ABSTRACT

Two studies explored the possibility of inducing conservation understanding in intellectually normal preschoolers and mildly mentally retarded children of comparable mental age. Retarded children, MA 3-10 to 5-0, received Verbal Rule instruction. Three- and 4-year-old children were given Verbal Rule training in a 2 x 2 x 2 factorial design intended to probe the importance of identity, reversibility, and compensation explanations in training number and length concepts, replicating an earlier study of retarded children (Field 1977). Results showed that both groups made considerable progress. Experiment I shows that many 4-year-olds can conserve, even when measured by Piaget's strictest criteria. Each group performed very similarly to older retarded and nonretarded children, except that the younger groups were not able, on average, to conserve as many quantities. It was found that the effects of MA and CA are different for immediate and the long-term posttests. Four-year-old children were able to generalize to untrained quantities far better than 3-year-olds, however, and in a follow-up posttest given 2 /12 to 5 months later, those children who had generalized, maintained or increased their conservation understanding while almost all 3-year-olds reverted to nonconservation. The studies reported extend downward about one year the age at which stable conservation can be achieved. (Author/RH)

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CAN PRESCHOOL CHILDREN REALLY LEARN TO CONSERVE?

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An abundance of research has been carried out investigating the possibility of inducing an understanding of numerous conservation concepts in school-aged children. Most recent studies have demonstrated that conservation can indeed be acquired by apparently nonconserving children of this age, although not all investigators have shown that their subjects acquired conservation in a manner which would satisfy Piaget's strict criteria:

"But when I am faced with these facts (training studies which have claimed cognitive changes with relatively weak evidence), I always have three questions which I want answered before I am convinced. The first question is, 'Is this learning lasting?' What remains two weeks or a month later? ... the second question is, 'How much generalization is possible?' ... then there is the third question, '... what was the operational level of the subject before the experience and what more complex structures has this learning succeeded in advancing?'" (Piaget, 1964, p.17-18)

I will suggest in this paper that it is necessary to show generalization to untrained concepts and continuing understanding of these concepts over considerable time in order to argue that the training has indeed led to a new level of understanding. This is as necessary in work with preschool children as it is with the older children who are the more usual subjects of study.

The paper will review studies which have attempted to train conservation in preschool children and then will describe two studies which show that

conservation can be induced in very young normal and mildly mentally retarded children.

In a very early study, Bruner (1964) found that five, six, and seven year old nonconservers of liquid quantity were able to learn to conserve in a screening procedure by focussing on the fact that it was still the same water which was being poured from one container to another. The screening helped the child to disregard the perceptual features which had previously been more salient to him, such as the higher water level in the thinner glass, and thus acquire an understanding of identity. However this training was not effective with preschoolers. None of the four year olds were able to grasp the idea of invariant quantity when the screen was removed: the perceptual features overwhelmed them and they reverted to nonconservation once again. Only liquid quantity was considered in this study, however, and only four training problems were given. In light of work carried out later, one wonders if the fours, too, with further training might have overcome the salience of the perceptual displays.

Sigel, Roeper, & Hooper (1966) trained preschool children, mean CA 4:4, through instruction in multiple labeling, multiple classification, and multiplicative relationality, reversibility, and seriation. They reported that the children acquired mastery of 1.6 concepts, on average. However, the study included only five experimental and five control children whose mean IQ was 144, so it is difficult to apply these results to the general preschool population.

Mermelstein & Meyer (1969) attempted to train over 400 children, about 20% of whom were 3½ to 5 years old. They used four training methods: Cognitive Conflict, Verbal Rule Instruction, Language Activation, and Multiple Classification. However, each of these methods was misinterpreted in important ways. It is not surprising that their hypothesis, that none of the training techniques would be successful, was proved.

Emrick (1969) provided Learning Set or Shaping training, with or without feedback, to 60 of the 77 preschool children, mean CA 4:4, he tested who passed

less than 25% of the conservation "items" of the pretest. He found that feedback was more important than the type of training, and that 73% of the children showed specific transfer of number and length, and 43% transferred to conservation of mass and "volume". In addition, he provided a second posttest, given two to three weeks after the first, and considerable stability of scores was shown.

Halford (1970) used a Learning Set procedure with seven training sessions, all of semi-continuous quantity (rice). His subjects included 15 preschool children, mean CA 4:0. He found that subjects five years or older showed improvement over problems, while the preschool children did not. He interpreted this to mean that "preschool children cannot construct the logical basis of conservation, whereas we have shown children over five show some ability to do so." (p. 11) More recently, Field (1974, Note 1) and others have shown that Learning Set is not the most efficient method for inculcating conservation understanding, particularly with young children. In addition, it is usually found that conservation of continuous quantity normally appears later than some of the other quantities.

Felgenbaum (1971) trained over 100 preschool children, mean CA 4:6, in small groups for six sessions in as many weeks. Training included reversibility/reciprocity, physical perspective taking, and social role playing. The posttest covered a broad variety of skills, including conservation, perspectives, and social role ability. All groups, including Controls, improved in conservation, but it appears that the pretest itself provided sufficient cues to lead to increased conservation. Reversibility/reciprocity training led to the greatest increase in conservation, but none of the treatments improved role-taking ability, which is not surprising.

Rosenthal & Zimmerman (1972) gave no-rule modeling training to a group of 13 children aged 4:2 to 4:9. The pretest, modeling, and posttest were given all in one session. It was found that children improved their scores significantly from baseline both in imitation and generalization if only judgements were considered. However, they were not able to supply

adequate justifications, and Rosenthal & Zimmerman concluded that "the linguistic components requisite for a formally adequate explanation were beyond the verbal repertoires readily accessible to these four-year-olds." (p. 399) Since no verbal explanation was provided during the modeling procedure, these very young children would have had to construct their own explanations, on the spot, in the posttest. There was no posttest separate from training, so it is not known whether the children maintained whatever understanding they acquired during modeling. Since the posttest so closely mirrored the modeling training, there is no reason to expect that these children had acquired anything more than an imitative response.

Bucher & Schneider (1973) conducted a long and involved experiment with preschool children. Forty-nine children, aged 3:1 to 5:0, mean CA 4:2, commenced the study, and 25 completed it. A minimum of 158 number relations trials and 236 conservation training trials were required to complete the graded training steps, and the children were seen individually for three to five sessions each week for three months. The children were trained in number, mass, and liquid, and all 25 children who completed training were reported to be successful, so 51% of the subjects acquired conservation of all three quantities in three months, and the rest may have learned to conserve none at all. This was an arduous task for all concerned; one wonders if the success rate might have been higher if training had been paced more briskly, or if the quantities had been assessed separately.

Greitzer & Jeffrey (1973) considered the effects of a pretest of length on the conservation of length after training. Their subjects, aged 4:0 to 5:2, were given Learning Set or Fading training, with or without pretesting. They found that children who had been pretested performed less well than those who had not in both training groups, although this effect reached significance only with Fading training. They suggest that pretesting "may increase the salience of misleading cues, in particular, that of the trans-

formation itself." (p. 435) Since the training and posttest were given in one session and no further posttests were given, it is not known whether these effects would have been found beyond the immediate experimental situation. It is possible that further training would have provided quite different results. Most of the studies which have successfully trained young children have used some method of distributed practice to achieve their results.

Brainerd (1974) conducted a study with preschool children of mean CA 5:2, somewhat older than most preschool populations. In the conservation training condition, twelve trials of length conservation stimuli were given. Different colored strings were presented, and verbal feedback was given. In the posttest one week later, these children scored 2.29 for length and 1.38 (out of a possible score of 4.00) for the generalization task of weight conservation. Brainerd (1977) reports that this means the subjects passed roughly 50% of the length items and roughly 34% of the weight items. The number of children passing each item is not given. Brainerd (1974) concluded that the "simple feedback" procedure produced stable performance because the posttest was given one week after training. Brainerd's feedback was more extensive than that generally found in Learning Set training, in that it included a statement, e.g., "You're wrong, the two pieces of string are still the same length." This statement provided more information than pure feedback, particularly the word "still", which implied identity.

Winer (1974) worked with three and four year olds on number conservation. He found that only two of the ten three year olds he tested could even understand the pretest question. These questions were indeed phrased in a manner which must have been confusing to these young children, for instance, "Do you have more, or do I have more, or do we both have the same number of checkers?" This writer recommends Rothenberg's (1969) very much simpler question format. Winer's training was with smaller (two rows of two checkers) or larger (two rows of five checkers), with one checker being added to one

of the rows for some problems. Winer found that the four year olds responded to standard conservation tests involving small quantities much better than the larger ones. He pointed out that this may have been a perceptual apprehension of numerosity rather than a true conservation response.

Zimmerman & Lanaro (1974) trained children, $\overline{CA} = 4:5$, in conservation of length. In this study one group was exposed to a model who made a correct conservation judgement and gave an invariant quantity rule: "Because they were both the same length before". A second group had in addition an unspoken demonstration of reversibility when the model pushed the rods back together while saying the rule. Two training sessions were given two days apart, and the posttest followed directly on the second training session. It was found that both experimental groups improved in length conservation, relative to the control group, but there was no significant difference in the performance of the two experimental groups. This finding agrees with my own that a verbal rule is required to draw the attention of such young children to what is actually occurring in the transformation; the mere demonstration of reversibility is not sufficient to call the attention of the child to it.

Miller, Heldmayer, & Miller (1975) examined number conservation in 64 children of CA 3:1 to 5:10 to determine how a rudimentary conservation understanding might be facilitated by perceptual supports. Although only seven trials were given, these may have functioned as training, for they found that older children were able to progress when the trials were arranged from easiest to hardest tasks, but not when the order was the opposite. Younger children did not learn.

May & Tisshaw (1977) gave a much modified Learning Set training of only eight problems to day care children aged 4:0 to 5:4. Some children were trained only on length, some only on number, and several groups had mixed length and number training in different arrangements. The posttest followed immediately on the training session; since most children were not pretested, it is difficult to interpret the posttest results. May & Tisshaw

found that for length and number conservation on the posttest, 12% of the control group conserved length, a surprising score for an untrained group of this age, none conserved number; in the mixed training groups, 62.5% conserved length, 44% number; the children who were trained on only one of the quantities fell between. They also found negligible transfer to liquid or mass conservation, though the children with mixed training generalized somewhat better. They concluded that variety in training leads to better results; many other studies, including those to be reported here, agree.

Danney, Zetinoglu, & Salzer (1977) studied children aged 4:0 to 4:11 in two experiments. They first compared training with and without Verbal Rule, and with and without feedback. They found that Verbal Rule with feedback was the sole effective training method for inducing conservation in these young children, but their one-session training of number and length concepts did not lead to transfer to mass conservation. In the second experiment, they trained length and mass, using only Verbal Rule with feedback, in one training session of 24 problems. In this second experiment they wisely did not include any number conservers in the experimental groups. They considered judgements and justifications separately, in the posttest given one week after training, and found significantly more correct judgements than justifications. However, if only those children who gave correct judgements and justifications were scored as conservers, they still would have found highly significant training effects. The length and mass training provided generalization to the easier number quantity and to weight as well. Their interpretation of the results included the observation that, according to Piaget, the child must possess the relevant cognitive structure before he will be able to assimilate verbally transmitted information. They then went on to say their subjects were too young to possess the relevant cognitive structures, even though in the first experiment they reported that of 41 children pretested, one conserved both

number and length, 11 conserved number, and several transitional children were found as well. Surely these children demonstrated that they possessed at least some of the relevant cognitive structures, and they were of the same age as the children of the second study. Denney et al (1977) also reported that the demonstrations which accompanied their rules may have made concrete and meaningful the abstract verbal rule, thus allowing these young children to assimilate conservation understanding. The independent varying of the Verbal Rule with demonstration, which they advocate, has been done in several experiments, and will be reported in this paper.

Brainerd (1977) recently reviewed some of these studies, and he noted "In short, credible evidence exists that preschoolers, like nonconservers of number, can be taught to conserve. ... Although learning effects may be somewhat smaller with preschoolers, it is crucial to note that all of the key qualitative findings that have been observed for older children (susceptibility to a variety of training methods, transfer of learning to untrained types of conservation, retention of learning across intervals of a week or more) have now been reported for preschoolers." (p. 933)

It certainly is true that training effects have been noted for four year olds and that these effects have persisted for a week or more.

But two important questions remain. First, is it possible to induce conservation understanding in preschoolers below the age of four? And if so, will they show a learning effect equal to that of the four year olds? Several researchers have shown that four year olds show a significantly smaller learning effect than older nonconservers; will this trend continue with three year olds? Second, how ephemeral are the effects of training on these very young children? Given that the effects may be retained for a week or more, as determined by several of the studies cited above, what might we expect if the children are tested again several months later?

Two studies will be reported here that directly examined these questions.

Earlier experiments of this series studied the effects of conservation training with mildly mentally retarded (ESN, since the work was done at Educationally Subnormal special schools in London) and nonretarded kindergarten-aged children in a London Infant School (Field 1974, 1978, Note 1). Influenced by the findings of other investigators, these earlier studies restricted subjects to those with MA $\geq$ 5:0. Results showed that Verbal Rule training was far more successful than Learning Set in leading to conservation understanding. These studies also included follow-up posttests, given from 4 to 16 months after the original experiment, and these showed that children trained by the Verbal method retained or improved their conservation skills, where other children did not. This was interpreted as convincing evidence that the Verbal training led to true conservation understanding, both in normal and in retarded children.

An obvious next step was to test the efficacy of the Verbal Rule with groups of younger children.

EXPERIMENT 1

Since it was shown that Verbal Rule instruction is an effective way to teach conservation skills to both retarded and nonretarded children, the next step was to tease out the causative elements, to separate the Verbal Rule into its components, and to determine how essential each one is to the acquisition of conservation understanding. A $2 \times 2 \times 2$ factorial design provided eight experimental groups, in which every combination of identity, reversibility, and compensation explanations were provided in the training sessions, as described below.

An earlier study using this design was carried out in London with the children from two ESN day schools (Field 1977, Note 1). It was found that there were, indeed, significant differences in conservation mastery depending on the training given, particularly in transfer to untrained quantities. Identity was the primary factor in conservation acquisition; reversibility was important as well; but compensation strategy proved to be of no value to these children.

Method

Subjects

Eighty-five three and four year old children, pupils at the two nursery schools of the Harold E. Jones Child Study Center, were pretested for conservation of number, mass, and length and were given the Peabody Picture Vocabulary Test. Thirteen children were rejected because they conserved one or more quantities, or were five years old. Nine were not chosen because their MA was below 36 months. The average age of experimental children was 4:3, s.d. 5.6 months; their mean MA was 5:5, s.d. 14.2 months, range 3:1 to 7:6. Twenty-one of these children were aged 3:0 to 4:0; 42 were aged 4:1 to 5:1. There were 30 girls and 33 boys. A wide variety of ethnic background and socioeconomic status was represented, although the average education of all parents was college graduate. Sixty-three children were arranged in nine

groups, closely matched on the basis of MA, CA, sex, and school. These groups were randomly assigned to treatment conditions. The nine groups included the combinations of three treatments and also a second, no-treatment control group, as described below.

Pretest

This included five subtests of number, mass, length, liquid, and weight, each of which had two transformations. A child who was a nonconservers of the first three quantities was not pretested for liquid and weight. As advocated by Rothenberg (1969), the questions were phrased as simply as possible, for instance:

"Are there the same number of checkers here (indicate with hand) as here (indicate)?"

"Does one row have more?"

(if child answers 'yes') "Which row has more?"

After each conserving or nonconserving judgement was made, the child was asked "How can you tell?", and the resulting justifications were coded as identity, reversibility, compensation, addition/subtraction, perceptual, or other. No child was scored as having acquired conservation of a quantity unless judgements and justifications given were adequate for that quantity. The child thus could score from 0 to 5 on the pretest or posttest, depending on how many quantities were mastered. This scoring method has proved useful in all studies of this series, and it is similar to that advocated by Beilin (1976).

There has been considerable controversy about the advisability of requiring justifications when testing the child's understanding (Beilin 1976, Brainerd 1973, Reese & Schack 1974). A study is now underway which will test differences in numbers of children rated conservers when only their judgements are considered and when correct justifications are required as well. In the studies to be reported here, a strict scoring criterion was adhered to. For instance, for number conservation, if a child responded to the

question "Are there the same number of checkers now?" by counting the checkers before answering, he was not rated a conserver. But if he immediately answered "Yes", and responded to "How can you tell?" by counting the checkers, he was scored as conserving that transformation with an identity justifications.

Training

Consistent with the earlier studies (Field 1974, 1978), each child was seen individually, each of the three training sessions was approximately six to ten days apart, the same materials and transformations were used, and each group received approximately the same number of tangible and intangible reinforcements. Treatment was identical for all groups save for one crucial difference: the content of the Verbal Rule.

The format was oddity training, adapted from that introduced by Beilin (1965) and Gelman (1969). In each problem three sets were presented at a time, and the child was always asked to pick the two rows which had the same number of sweets, or draughtsmen, etc; or for length problems, the child was asked to indicate which two sticks, ribbons, wires, etc., were the same length. In the original presentation of each material, the sets were arranged in such a way that all cues were "relevant and redundant" (Gelman, 1969, p. 175), but the two transformations which followed required the child to focus on the relevant dimension of length or number in order to indicate correctly the two elements of the set which were the same number or length.

Five number problems preceded five length problems in the first two sessions, and the order was reversed in the third training session. The problems were arranged in a graded difficulty: smaller numbers of elements were presented in the earlier sessions, as well as perceptually easier transformations. The children were so successful in their training problems that it seemed almost to be an errorless learning procedure, and many tangible and intangible reinforcements resulted. Number problems used cellophane-wrapped candies, small brightly colored plastic sheep, standard jacks, checkers,

and small flat squares of plasticene. Length problems were presented using square dowelling sticks, round pink-stained dowelling rods, bright yellow velvet ribbons, lengths of electric wire which held their shape when bent or twisted, and square dowelling sticks which had been cut into 5 cm. lengths. All length materials were 15, 20, or 30 cms. long, and all number sets were presented with 3 and 5, or 5 and 7 to a set. These interesting and varied materials have proved to be appealing to almost all children. The variety of materials and the many possible transformations no doubt have played an important role in the success of these training experiments.

Each time the child made his choice of which two of the set were the same he was given feedback and also the Verbal Rule. All correct choices were also reinforced by the dropping of a brightly-colored counter into a glass jar.

The content of the Verbal Rule was the sole variable manipulated in the treatment of the groups. If the child was in Group I, R, or C, he heard identity (I), reversibility (R), or compensation (C) explanations 60 times. Those children in the IR, IC, or RC groups heard explanations evenly divided between the two aspects, 30 of each. The IRC group members heard approximately 20 of each of the three types of explanation.

Identity explanations all stressed the equivalence of the materials. The child might be asked to count the elements in the three rows; or the experimenter might explain that moving the sticks or bending the wire did not alter their length; "It's still the same ribbon." "No matter where you put them, the number of sweets is just the same."

Reversibility explanations emphasized the fact that the operation can be reversed to yield the same materials. "Look; we just have to put the sticks back together to see that they're the same length." "If we put the jacks back in the row the way they were, you will see that they match the other row."

Compensations explanations pointed out that a change in one dimension

was balanced with a change in the other. "Yes, this stick does go farther in this direction; but look here: at the other end the other stick is going farther, so they are balancing each other." "This row of plasticene bits is very much stretched out, so that it is a lot longer than the others, but look at all the spaces between the bits. That's what makes the row so long, for in the other rows the plasticene is so much closer together." "But look, we tied this shorter ribbon to your finger, and we tied the longer ribbon around your wrist. Your wrist is bigger, so it took a longer ribbon to go all the way around and still have enough left to tie."

One might expect that such complex explanations would be beyond the capacity of such young children, but they became so caught up in the "games" that the demonstrations accompanying the explanations seemed to make good sense to them.

The Control Group in which identical problems were given and individual attention and reinforcements were comparable was a Learning Set group. Here feedback was provided but no verbal explanations were given at all.

The second Control Group also was seen three times and received approximately the same number of reinforcements, but no training. Each Control child played the game of checkers or carried out pattern matching activities using a large number of black and white checkers with the investigator.

Posttest

The posttest was identical to the pretest, and always included all five quantities. It was given approximately one week after the third training session.

Delayed Posttest

A second posttest was given after $2\frac{1}{2}$ or 5 months. The time difference resulted from school holidays and scheduling of the total experiment. Two of the nursery classes, a morning group of three year olds and an afternoon class of four year olds, were tested after $2\frac{1}{2}$ months; the other two classes, also an afternoon and a morning class, were tested after 5 months. This posttest

was identical to the earlier posttest in form and content. There were no significant differences in the posttest performances of those children tested after the shorter interval and those tested later.

Results

Natural Conservers

Nine of these children were not yet five years old. Their mean age was 4:7, range 4:3 to 4:11. Their MA was considerably higher than the non-conservers, mean 7:1, range 4:11 to 8:5. This differed significantly from the mean MA of 6:1 of the 27 experimental children whose CA fell in the same range, $t(34) = 2.88$, $p < .01$. Of these nine natural conservers, five conserved number only, three conserved two quantities, and one conserved four quantities on the pretest.

Insert Figure 1 about here

Training

A multivariate repeated measures analysis of variance found no significant main effects or interactions in training except for the time effect: the change in scores from Session 1 to Session 3 showed a highly significant linear trend, $F(2,37) = 23.5$, $p < .0001$. The means for all groups were 22.5, 23.8, and 25.0, s.d.s 4.82, 4.46, and 3.72, of a possible 30. Because the training had been designed to elicit a high proportion of correct responses from the children, significant differences between the groups were not found. However, a multivariate repeated measures analysis of variance found highly significant differences in the training scores of the three year olds compared with the four year olds, $F(3,52) = 14.14$, $p < .0001$. This comparison is depicted in Figure 1.

Insert Table 1 about here

Posttest

Effects of training on conservation acquisition. Scores on the posttest made clear the strong effects of the verbal training. Table 1 shows that the identity effect is the most powerful, $F(1,48) = 24.45$, $p < .001$. Reversibility is important as well, $F(1,48) = 11.16$, $p < .03$, but a compen-

sation strategy was not valuable in inducing conservation acquisition. Mean scores for each Group, to be distinguished from effects, are shown in Table 2.

Insert Table 2 about here

Figure 2 shows the conservation scores of the 56 trained children of Experiment 1. Recall that two quantities, number and length, were trained, but five were included in the posttest. Those children who conserved more than two quantities demonstrated generalizations not only in their judgements but also by providing adequate justifications on both transformations of the quantity.

The training received by the Learning Set group was not sufficient to induce conservation in these children: Group L scores were not significantly different from those of the Control group.

Insert Figure 2 about here

Effects of age on conservation acquisition. Figure 2 shows that regardless of training, children above 48 months of age were able to acquire conservation of more quantities, on average 2.38, than those 48 months or younger could do, average 1.00, $t(53) = 3.32$, $p < .01$. These scores were found to be lower than those of two earlier studies: the verbally trained older normal children (CA 4:11 to 5:9), mean 2.63, or the older ESN children (MA 4:11 to 8:5), trained in the I-R-C factorial study, mean 2.72.

Effects of mental age on conservation acquisition. A multiple regression analysis examined the effects of MA and CA in predicting scores on Posttest I for all verbally trained children. The simple correlation of CA and Posttest was .426, the partial correlation of MA was .547, and the multiple correlation including both of these effects was .653. When MA was entered first the simple correlation of MA and Posttest was .639, and the partial correlation of CA was .174. Variability explained by both these variables was 43%, a considerable

amount since the analysis did not account for training effects, which we have seen earlier were powerful. For the first posttest, the effect of MA was more important than that of CA.

Sex of Subject. As has been found in all experiments of this series and many others (e.g., Rothenberg, 1969), sex of subject was not a determiner of conservation acquisition. In Experiment 1, however, a trend was seen toward a significant sex difference, with the mean score for girls, 1.54, s.d. 1.55, lower than that for boys, 2.33, s.d. 2.41, $t(53) = 1.92$, $p < .10$. This was puzzling until the CAs were compared and it was found that the boys were older, $\bar{CA} = 4:4$, than the girls, $\bar{CA} = 4:1$, as well, $t(53) = 2.16$, $p < .05$. Since a strong correlation was found between CA and conservation mastery, this explained the small sex difference.

Second Posttest

Effects of training over time. Results here were not in accord with those of most earlier studies of this series, for in this experiment group differences became blurred in the 2½ to 5 months between posttests. The 2 x 2 x 2 analysis of variance showed that the identity effect was marginally significant for all quantities together, $F(1,48) = 3.35$, $p < .074$; for number, $F(1,48) = 2.46$, $p < .12$; for mass $F(1,48) = 2.59$, $p < .11$; and for length, $F(1,48) = 3.58$, $p < .064$; and the IC interaction approached significance for liquid ($F(1,48) = 3.87$, $p < .055$). No other main effects or interactions approached significance any longer.

Table 2 shows group scores for the follow-up posttest. Two of the groups had modestly increased scores, two maintained their scores, and five showed losses in group scores.

Closer examination suggested a reason, however, for this blurring of group differences, for striking differences in the scores of younger and older preschoolers were found.

Effects of age on continued conservation mastery. Figure 3 charts the results of the test given 2½ to 5 months after the end of training. The im-

portance of CA > 48 months in the retention of conservation is apparent in the Figure. All but two of the children younger than four years lost the apparently tenuous conservation understanding which they exhibited on the first posttest. This finding supports Piaget's (1964, 1974) and Beilin's (1976) insistence that only testing over time can prove a genuine stable conservation acquisition.

Insert Figure 3 about here

Figure 3 also makes it clear that many children CA > 48 months improved their conservation understanding in the interval between posttests, even though no training was given. Apparently many of the children who had acquired true conservation continued to profit from their training experience, restructuring and increasing their understanding in the time between posttests. Only one of the 14 trained but still nonconserving children acquired conservation of any quantities in this time; and two Control children had acquired conservation of number.

On the second posttest only 17% of the three year olds conserved one or more quantities, while 73% of the four year olds did so. None of the three year olds increased their scores, seven dropped, and of the 12 who maintained the same score, nine were nonconservers in both tests. The four year olds, however, provide different results. In spite of the fact that no training had been given between the posttests, 12 children increased their scores, 11 dropped, and of the 14 who maintained the same score, only five were nonconservers. This difference between the three and four year olds, examined with a log linear analysis, was significant, $\chi^2_2 = 16.8$, $p < .0002$.

Effects of mental age on continued conservation mastery. A multiple regression analysis examined the effects of CA, MA, and Posttest I on the follow-up posttest scores of the verbally trained children. It was found that the score from the first posttest, which was highly significantly related to training given, was strongly predictive of the score on the second

posttest, $r = .698$. When the effect of CA was added, the predictive power increased considerably, $r = .768$, and 60% of the variance was explained. The addition of MA to the regression equation added only marginally to the correlation, $r = .769$. This Posttest II result, that CA is more important than MA in predicting long term conservation acquisition, is quite different from that of Posttest I, where MA exerted more influence than CA on the scores.

Other results. The school attended had no relationship to results in either posttest. The time elapsed between posttests made no difference.

EXPERIMENT 2

A study to investigate the possibility of successfully training children with MAs less than five years was carried out in London with mildly mentally retarded children. Although only 12 children in the ESN school met the criteria of nonconservation, $MA < 5:0$, and comprehension of the task of matching two rows of checkers, the results are consistent with those found with other, larger groups of retarded as well as nonretarded children.

Method

Subjects

There were six children in the Verbal group and six in the Control group. In both groups the MA, as measured by the Peabody Picture Vocabulary Test, ranged from 46 to 61 months; for the Verbal group the mean MA was 4:4, s.d. 5.46 months, and the Control mean MA was 4:3, s.d. 6.19 months. CAs were 6:9 to 11:3 years. The Pretest for all of them was as described in Experiment 1.

Training

The same oddity problems were presented as those described in Experiment 1. The same materials and transformations were used, and the three training sessions were approximately six days apart.

In Experiment 2, the investigator used whatever explanations seemed to be most natural in the situation, except that each session was planned to be more difficult than the one before it. All explanations were examples of identity, reversibility, or compensation. The Control children participated in pattern matching activities with black and white checkers; this provided a comparable amount of individual attention and tangible and intangible reinforcements as received by the verbally trained children.

Posttest

The posttest was as described in Experiment 1.

Further Training

Because these children were younger in CA and lower in MA than other

retarded children, it was felt that they might profit from further training, so two more sessions, using the same materials and transformations similar to those of Session 2 and 3, were given about a week apart. A second posttest, identical to the first, was administered five to seven days after training session 5.

Delayed Posttest

It was possible to retest all children $3\frac{1}{2}$ months after Posttest 2; this test was identical to those which preceded it.

Results

Training

As has been found in other studies as well, the multivariate repeated measures analysis of variance showed that training scores improved with a significant linear trend, $F(1,4) = 16.99$, $p < .015$. From Session 1 to Session 5, the scores were 20.3, 21.5, 24.0, 25.8, and 26.0. The highest possible score was 30, so it is evident that these children performed very well in training, although in an earlier experiment (Field 1974) an equivalently trained group of older-MA ESN children, who had been given only the first three training sessions, had scored even higher (27.5, 28.0, and 28.3).

Insert Table 3 about here

Posttest I

The posttest given after three training sessions found that all six verbally trained children conserved number and length. This, then, was perfect specific transfer. There was no nonspecific transfer, for none of the other quantities were consistently judged and justified correctly, although there were scattered correct responses. Results for all Posttests are shown in Table 3.

Posttest II

After the two further training sessions, the verbally trained ESN children had improved their conservation understanding. No child regressed, and three managed to generalize to one further quantity: two to mass and one to liquid.

Posttest III

The follow-up, given $3\frac{1}{2}$ months after the second posttest, but without any further training of the children, found slight further gains in the verbally trained children. All of them continued to show perfect specific transfer, three children now generalized to untrained quantities, and one of them had added a fourth quantity to her repertoire. The Control children gave somewhat more scattered correct responses, but none of them arrived at an understanding of conservation of any quantity in the nearly five months over which they were seen.

A repeated measures analysis of variance of the three posttests found a marginally significant improvement in the scores of the trained children, $F(2,10) = 3.73$, $p < .05$.

DISCUSSIONPreschoolers

The evidence presented here is in agreement with Brainerd's (1977) conclusion that preschoolers can be taught to conserve, if only the four year olds are considered. All of the studies cited by Brainerd were concerned with four year old preschoolers, and none included three year old children. The evidence of Experiment 1 is clear that many four year olds can acquire a real understanding of conservation, even when measured by Piaget's strictest criteria. But far fewer three year olds could do so, and even that understanding was short lived, as shown in the delayed posttest.

Follow-up Posttest

So far as is known, no other studies of young children have included a delayed posttest. Brainerd (1974) tested his children after seven days; Zimmerman & Lanaro (1974) after 9 days, and Emrick (1969) after two to three weeks. A test of conservation given after a considerable interval, as done in Experiments 1 and 2, allows one to determine whether true cognitive structural changes were effected. Here we found that in most

cases only those children who had gained sufficient understanding to generalize to untrained concepts, and these were the older children, demonstrated permanent cognitive changes. Surely this is the crucial test.

Effects of Mental Age

One of the most intriguing findings of the study is that the effects of MA and CA are different for the immediate and the long-term posttests. On the first posttest the best predictor of performance, aside from training method, was the MA of the child. One can imagine these bright little children, accustomed both by their school and home experiences to solving many different sorts of problems, attacking the problems presented by these new "games" with the strategy which was provided by the verbal training. This strategy worked well for them, so well that many of the children were able to generalize to other than the trained concepts, on the first posttest.

Later, however, after $2\frac{1}{2}$ to 5 months had passed, more than a strategy was needed. Those 22 children, all but two of whom were four years old, who maintained or improved in their conservation performance over time gave evidence of changes in their cognitive structures which is much more persuasive than that presented at the first posttest.

The Importance of Chronological Age

Why is it that clearly preoperational four year olds were able to acquire a stable conservation mastery and one-third of them were able to increase this understanding on their own? Their performance was in sharp contrast to that of the three year olds.

Beilin (Note 2) observed that in many training studies the differential effects of age on training are considerable, that older and more advanced children show training effects which are superior to those of younger children. The studies reported here agree with this observation, but they have extended downward about one year the age at which stable conservation can be achieved.

Bruner's (1964, 1966) early work demonstrated that training can lead to conservation in children five years or older but that training was not effective for four year olds. The Verbal Rule offered in the present studies, with the varied and attractive games, the three short training sessions spread over two to three weeks, the individual attention, and the many tangible and intangible reinforcements, seems to have been a particularly appealing vehicle for learning for these young children. Nevertheless, in the long run it was only the four year olds who were able to use this experience to effect a permanent cognitive change.

Beilin (Note 2) suggested that "brute" or forced methods, as he described Verbal Rule instruction, can force assimilation to the simplest available structures, but these will not lead to generalization for young children. This explanation fits well with the long-term results of the three year old children observed in this study. As for the four year olds, Beilin noted that

"older, and transitionally operational children, however, who have more developed preoperational schemes (one-way mapping of constituent structures) will provide a more stable base for the assimilation of forced strategies or solution algorithms, or lead to the forced restructuring of incomplete or unintegrated structures." (Note 2, p. 19)

Those four year old children who retained their conservation understanding over time gave ample evidence that restructuring had indeed taken place.

Comparison of Mentally Retarded and Nonretarded Children

The children were comparable in many ways. Although the ESN children were older, their mean MA of 4:3 was comparable to the mean CA, 4:3, of the nursery children. Results of Experiment 1, however, show that MA is not the only important factor in conservation acquisition.

In both experiments children had to be rejected as subjects because they could not comprehend the point of the games. No ESN child of MA below 3:10 could satisfactorily work with the problems, while there were eight nursery children whose MA was less than 3:10 who clearly did respond appropriately in the experimental situation, and the lowest MA included was 3:1.

There were five young nursery children, MA 2:1 to 2:10, however, who behaved very similarly to those ESNs whose MA was lower than 3:10: they were delighted to have the attention of the investigator and to play the "games" on several occasions, but they could not ever grasp the point of the problems, their attention was very unstable, and no progress could be made in training.

A comparison of the two I-R-C studies (Field, Note 1) shows that there is a striking similarity in the effects of training in these two very different groups of children, ESN and young normal. Since this paper is concerned primarily with the training of preschool children, these results will not be discussed here, except to observe that this similarity must be considered evidence of the importance of the identity construct in the acquisition of Piagetian conservation concepts. Identity was shown to be the most effective form of explanation for both groups of children.

A difference between the ESNs of the I-R-C study (Field 1977) and the nursery children was in the amount of weight conservation demonstrated. Fourteen of the 42 ESN children conserved weight on the first posttest, but only three of the nursery children managed to do so, $\chi^2_{(1)} = 6.83$, $p < .01$. Figure 3 does indicate, however, that on the second posttest six nursery children conserved all five of the tested quantities, including weight. The consolidation of conservation competence which was shown by children who had learned to generalize their understanding beyond the trained quantities on the first Posttest is particularly evident here.

Only two of the trained ESN children had an MA below four years, 3:10

and 3:11, so it was not possible to compare the performance of children of lower and greater MA. All the ESN children did learn to conserve, in contrast with the nursery four year olds, and all the ESN children did retain their understanding from one posttest to the next, also in contrast to some of the four year olds. This appears to be another indication of the importance of CA in conservation acquisition.

The Importance of Strict Criteria

All of the criteria prescribed by Piaget (1964, 1974) were met in these studies. The original operational level of each of the children was assessed by the pretest, and only those children who demonstrated no conservation understanding were included in the experiment.

In a review of training studies, Kuhn (1974) considered the role of appropriate explanations, persistence over time, and resistance to counter-suggestion, and concluded that the "generalization criterion deserves the status of the critical one" (p.593) in determining whether conservation has "really" been acquired through experimental procedures. If the child can be shown to be able to make correct judgements and justifications in concept areas which were not part of his training, he "must have acquired something more than a set of specific rote-learning responses." (p.593) Indeed, he has demonstrated the ability to use the acquired strategy in varied ways. This can be said with even greater assurance when the child tailors his justifications to fit the quantities he has learned to conserve, as has been seen in these studies. (Field, 1977, 1978).

Finally, the importance of testing over time was amply demonstrated as well. Indeed, the long-term follow-up showed that in almost all cases those children who had acquired a generalized understanding at the time of the first posttest continued to generalize, to conserve quantities in addition to those with which they had been trained, for up to five months.

This study has added to our understanding of cognitive development in three and four year old children, and it has done so within the rightly strict criteria proposed by Piaget.

Reference Notes

1. Field, D. Identity, reversibility, and compensation: An examination.
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2. Beilin, H. Piaget's theory: Refinement, revision, or rejection? Paper
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Table 1
The Effects of Training
on Posttest Scores, Experiment 1

Effect	Total (all quantities)		Number		Mass		Length		Liquid		Weight
	F	p	F	p	F	p	F	p	F	p	
*I	12.08	.001	15.84	.001	1.71		7.89	.007	3.97	.052	was not analyzed, since only three Ss conserved
*R	5.52	.023	.84		6.86	.012	1.26		3.97	.052	
*C	.08		.84		1.71		1.26		.73		
**IR	.22		.84		.00		1.26		.08		
**IC	3.89		2.34		6.86	.012	1.26		.08		
**RC	.72		.09		1.71		.32		.08		
**IRC	.43		.09		1.71		.32		.08		

Note: all F(1,48)

* main effect

** interaction effect

Table 2
Posttest Scores for Each Group
Experiment 1

First Posttest

	R		$\bar{R}$	
	C	$\bar{C}$	C	$\bar{C}$
I	2.14	3.40	2.00	2.29
$\bar{I}$	2.00	1.43	1.00	.86

Second Posttest

	R		$\bar{R}$	
	C	$\bar{C}$	C	$\bar{C}$
I	2.60	2.00	2.00	2.17
$\bar{I}$	2.00	1.20	1.57	.71

Note: The no-training Control Group
scored .29 on the first Posttest
and .50 on the Second Posttest

Table 3
Posttest Scores for Young ESN Children

Verbal Group				Control Group			
Subject	Post I	Post II	Post III	Subject	Post I	Post II	Post III
1	2	2	2	7	0	0	0
2	2	3	3	8	0	0	0
3	2	2	2	9	0	0	0
4	2	3	4	10	0	0	0
5	2	3	2	11	0	0	0
6	2	2	3	12	0	0	0
Mean	2	2.5	2.67		0	0	0

Figure 1
Comparing Training Scores
of Three and Four Year Olds





